ARMY RESEARCH LABORATORY

Close-Quarters Combat Shot Shell

by Robert P. Kaste

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Abstract

The theory and design for a shot shell that produces a wider-than-standard shot spread are described. The technique implemented utilizes the pressure generated by the propulsion charge to apply radial force on the shot column within the shotgun barrel, causing an increase in shot divergence upon exit from the weapon. The increase in shot pattern size is intended for application of the shotgun as an area weapon for close-quarter applications, which might occur in military operations on urban terrain (MOUT) or civilian policing operations.

Acknowledgments

The author wishes to thank Andrew Brant of the U.S. Army Research Laboratory (ARL) for his time and effort producing the interior ballistic calculations used in this study. Dr. Lawrence J. Puckett is also to be commended, largely through his doggedness, for providing the funding to perform this project. Grateful appreciation is extended to Dennis Henry, who provided tremendous help performing the experiments and collecting the data. Thanks is also extended to the ARL model shop for their excellent work in fabrication.

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1. Background

While a shotgun is perceived as an area coverage weapon, its effectiveness as an area weapon is extremely limited in short-range, close-quarters, antipersonnel engagements such as those encountered inside a room or building during military operations on urban terrain (MOUT). A 12-gauge riot shotgun produces a shot divergence angle of only 3°–4°, clearly not effective for close-quarters area coverage (Figure 1). In order to cover an area 54 × 54 in (1.372 × 1.372 m) at a range of 15 ft (4.572 m), an angle of divergence of about 17° is required. This report discusses an effort to increase the size of the shot pattern using the concept described in U.S. Patent Numbers (Nos.) 5,191,168[1] and 5,192,830[2] (Figures 2[a] and 2[b]). The increase would be achieved by the development of a novel internally pressurized pusher "sabot," or cup, to replace the current cup, coupled with alternative shot stacking patterns and placement within the shell casing. A cooperative research and development agreement (CRDA) between the U.S. Army Research Laboratory (ARL) Weapons Technology Division (WTD) and H. P. White Laboratory, Inc., was established to pursue the concept, which is believed to have military, law enforcement, and sporting use. In this CRDA, the necessary analytical and experimental work required to explore a practical solution was shared by both the participants, with WTD performing the bulk of the analytic work.

While an increase in shot pattern size is desirable for the close-quarters application, it is also important to consider the effectiveness on the area covered. If the shot pattern is spread too thin, the impact energy delivered to a soldier-sized target will be so low as to render it ineffective. Conversely, if each pellet has enough energy to be in itself effective, the target size that could be covered by a single round would be limited by the total number of pellets fired. The number of pellets would be constrained by the interior ballistic design (i.e., the pressure rating for a shotgun barrel that is affected by the total launch mass for a given launch velocity). Appendix A presents the muzzle energies of some commonly used rounds and describes the process used to determine the desired total target area. A 12-gauge shotgun shell supplies a considerable amount of energy (about 1646 ft·lb or 2232 N-m). A single shot shell, in principle, could inflict damage to multiple people based on its available energy alone. However, it is impractical to engage too large a target. This, too, is described in Appendix A.

[1]Puckett, L. "Sabot for High Dispersion Shot Shell." U.S. Patent No. 5,191,168, 2 March 1993.
[2]Puckett, L. "Sabot for High Dispersion Shot Shell." U.S. Patent No. 5,192,830, 9 March 1993.

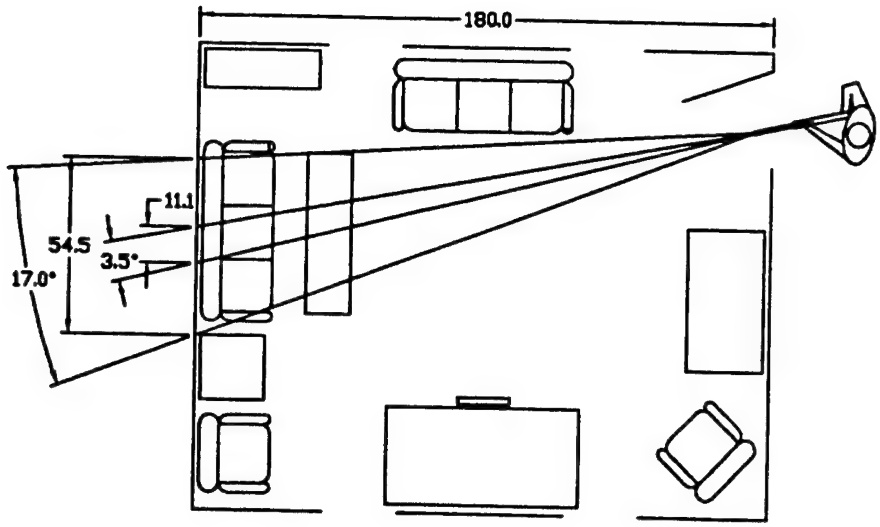


Figure 1. Area coverage of a shotgun.

Preliminary calculations for determining the pressure loading required to achieve the desired shot pattern are presented in Appendix B. Interior ballistic calculations were made to determine what pressures would be available at the muzzle for various length shotgun barrels. It was obvious that a shotgun with a barrel of any significant length would not have the necessary muzzle pressure to substantially increase the size of the shot pattern. However, as sufficient pressure is available earlier in the ballistic cycle from the propulsion gases, and as the volume within the shot cup is sufficiently small as to cause only minimal change to the interior ballistic combustion conditions, departure from the original patents was taken to include the concept of pressurizing and the maintaining of pressure within the shot cup (this resulted in U.S. Patent No. 5,644,100).[1]

2. Shot Cup Designs

ARL produced and tested several shot cups with internal cavities for the propulsion gas to pressurize, creating radial loading on the shot as it traveled down the shotgun barrel. The designs tested are depicted in Figure 3. Unaltered,

[1]Puckett, L., and R. Kaste. "Sabot for High-Dispersion Shot Shell." U.S. Patent No. 5,644,100, 1 July 1997.

US005191168A

United States Patent [19]

Puckett

[11] Patent Number: 5,191,168

[45] Date of Patent: Mar. 2, 1993

[54] SABOT FOR HIGH DISPERSION SHOT SHELL

[75] Inventor: Lawrence J. Puckett, Churchville, Md.

[73] Assignee: The United States of America as represented by the Secretary of the Army, Washington, D.C.

[21] Appl. No.: 828,321

[22] Filed: Jan. 29, 1992

[51] Int. Cl.[5] F42B 7/02

[52] U.S. Cl. 102/457; 102/520; 102/532

[58] Field of Search 102/443, 448–461, 102/439, 489, 520–523, 532

[56] References Cited

U.S. PATENT DOCUMENTS

579,429	8/1897	Elliott .	
820,459	4/1906	White .	
875,762	12/1908	Winans et al. .	
1,941,336	9/1933	Barbieri .	
3,261,282	7/1966	Hendricks	102/453
4,006,688	1/1977	Craft et al. .	
4,167,904	9/1979	Ferri	102/457
4,800,816	1/1989	Meyer	102/523
4,882,996	3/1989	Bock et al. .	

FOREIGN PATENT DOCUMENTS

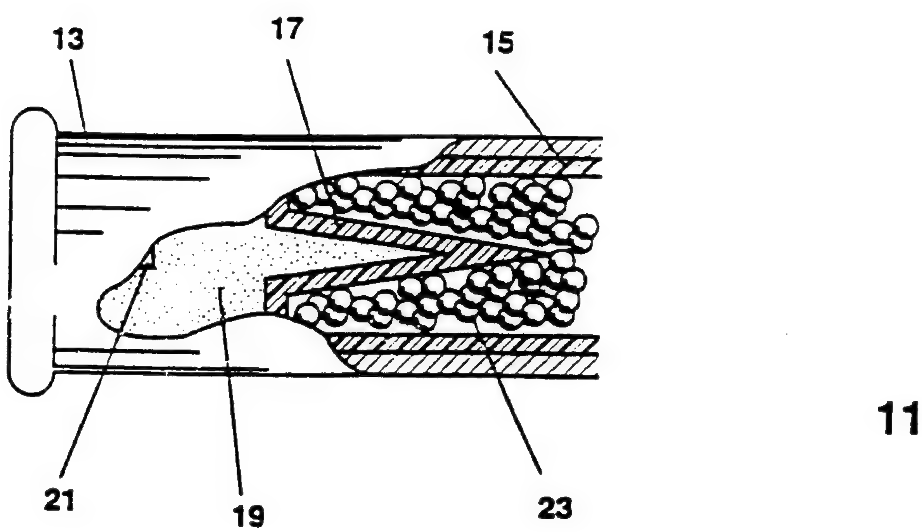
92430	11/1968	France	102/532

Primary Examiner—Harold J. Tudor
Attorney, Agent, or Firm—Saul Elbaum; Jason M. Shapiro

[57] ABSTRACT

A sabot for a shotgun shell provided with a recess in its base upon which propellant gases may act to radially expand and flatten the sabot thereby enhancing the dispersion of shot. In alternate embodiments the recess may be conoidal, parabolic, pyramidal, or an involute surface resembling a cone. The recess may also be comprised of multiple overlapping layers. Each recess provides a unique shot pattern for short-range antipersonnel engagements. In other embodiments, the foregoing recesses are provided with grooves to facilitate petalling of the recess and flattening of the sabot during and after launch. In another embodiment, the recess is filled with propellant and capped with a consumable plug to delay ignition of the propellant charge, further enhancing shot dispersion.

13 Claims, 5 Drawing Sheets



(a)

Figure 2. Patent concept.

US005192830A

United States Patent [19]

Puckett

[11] Patent Number: 5,192,830

[45] Date of Patent: Mar. 9, 1993

[54] SABOT FOR HIGH DISPERSION SHOT SHELL

[75] Inventor: Lawrence J. Puckett, Churchville, Md.

[73] Assignee: The United States of America as represented by the Secretary of The Army, Washington, D.C.

[21] Appl. No.: 931,469

[22] Filed: Aug. 21, 1992

Related U.S. Application Data

[62] Division of Ser. No. 828,321, Jan. 29, 1992.

[51] Int. Cl.⁵ F42B 7/02; F42B 14/06

[52] U.S. Cl. 102/457; 102/449; 102/522; 102/532

[58] Field of Search 102/439, 443, 448–457, 102/460–463, 489, 506, 520–523, 532

[56] References Cited

U.S. PATENT DOCUMENTS

579,429	3/1897	Elliott .	
820,459	7/1906	White .	
875,762	3/1908	Winans et al. .	
1,941,336	6/1933	Barbieri .	
3,261,282	7/1966	Hendricks	102/453
4,006,688	2/1977	Craft et al. .	
4,167,904	9/1979	Ferri	102/451
4,800,816	1/1989	Meyer	102/523
4,882,996	11/1989	Bock et al. .	

FOREIGN PATENT DOCUMENTS

1262557	4/1961	France	102/449
92430	11/1968	France	102/532

Primary Examiner—Harold J. Tudor
Attorney, Agent, or Firm—Saul Elbaum; Jason M. Shapiro

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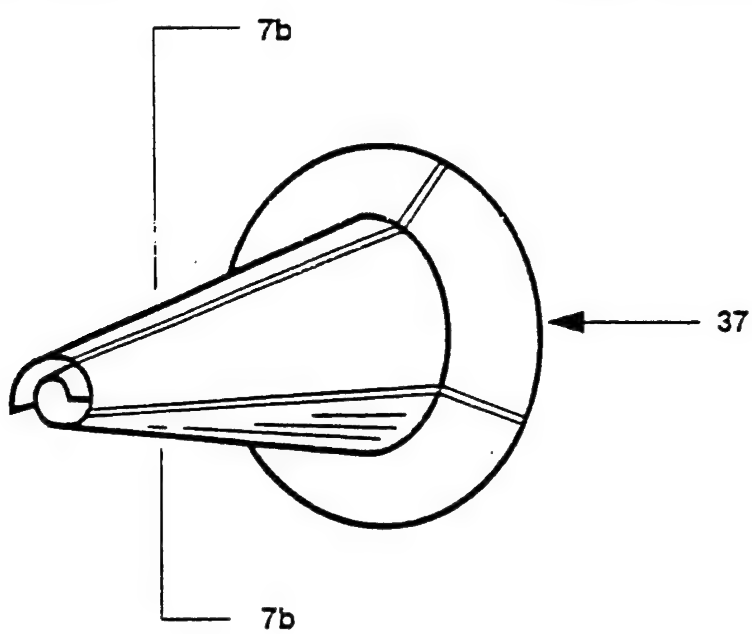
A sabot for a shotgun shell provided with a recess in its base upon which propellant gases may act to radially expand and flatten the sabot thereby enhancing the dispersion of shot. In alternate embodiments the recess may be conoidal, parabolic, pyramidal, or an involute surface resembling a cone. The recess may also be comprised of multiple overlapping layers. Each recess provides a unique shot pattern for short-range antipersonnel engagements. In other embodiments, the foregoing recesses are provided with grooves to facilitate petalling of the recess and flattening of the sabot during and after launch. In another embodiment, the recess is filled with propellant and capped with a consumable plug to delay ignition of the propellant charge, further enhancing shot dispersion.

4 Claims, 4 Drawing Sheets



(b)

Figure 2. Patent concept (continued).

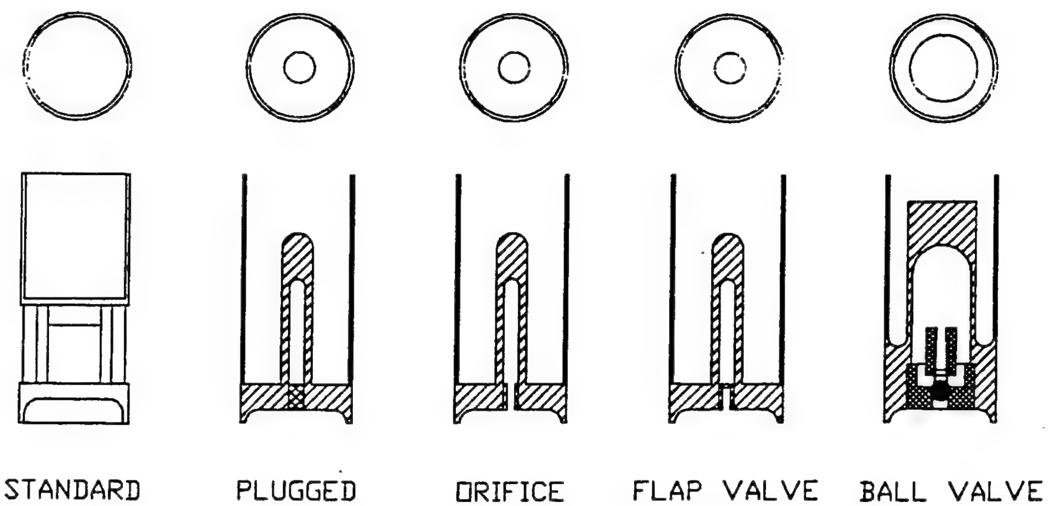


Figure 3. Shot cup designs.

factory-loaded shells and reloaded factory loads were tested to ensure the reloading was not affecting the shot spread. A cavity open to propulsion gas pressure was tested. A control test was performed with the orifice to the cavity plugged to determine if the cavity was being pressurized. A simple flap valve design was produced to capture the peak pressure reached within the cavity of the shot cup. This design was tried as a simple low-cost method of including a check valve mechanism. In order to prove the principle of the concept, ARL designed and tested another shot cup utilizing a ball check valve with a seating spring and much greater orifice area. The details of this design are shown in Figure 4. Additionally, in this shot cup, the shot cup volume (and hence the amount of shot) was reduced to ensure that the pressurized cavity would force the shot against the fingers of the shot cup and therefore against the gun bore. All of the ARL shot cups were fabricated in-house from low-density polyethylene stock. Low-density polyethylene has good strength and ductility properties, but was chosen primarily because it can be bonded and welded. Some attempts were made with various adhesives to create strong bonds with the polyethylene, but the structural integrity of the bonds was not satisfactory. Welding the polyethylene worked much better than the adhesives tried. The plastic orifices, plugs, and valves were welded to the shot cup (and the ball valve assembly was welded together) using a small pencil-type soldering iron.

3. Method of Testing

Factory-loaded federal 12-gauge shotgun shells with 1 1/4 oz of no. 7 1/2 shot were taken apart to obtain the powder and the shot. The original components (shot and shot cup), as well as the shot cups to be tested, were weighed. The powder was

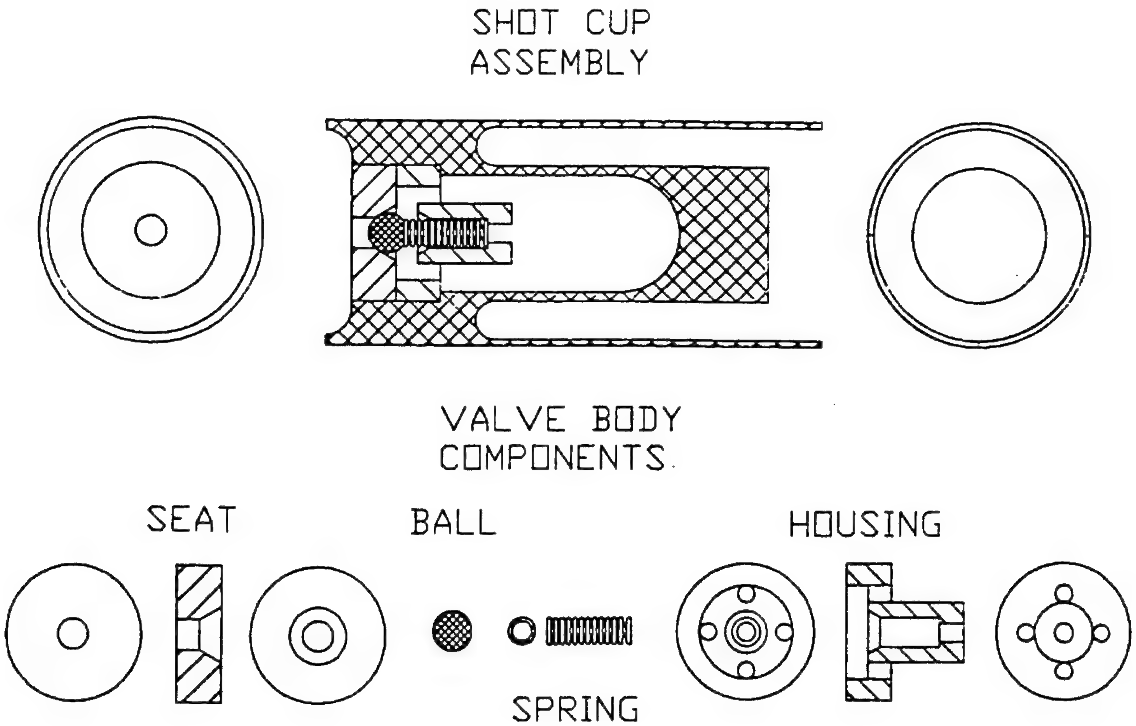


Figure 4. Ball check valve design.

reloaded into new primed cases along with the shot cup being tested and the proper amount of shot to make the weight of the test shot cup and shot equal to the weight of the original shot cup and full load of shot. The shot shells were assembled and crimped using an MEC model 8447-600 Jr. Mark V shot shell reloader.

The shot shells were fired from a Remington 20-in (508-mm) barrel pump feed "riot" shotgun at brown paper "witness" targets located 15 ft (4.572 m) from the gun's muzzle. For each test, a single round was loaded into the shotgun and fired. The gun was mounted to a hard stand and fired remotely with a lanyard.

The paper targets were marked with the test number and target orientation and removed after each shot. The extreme vertical and horizontal spreads were measured and recorded.

4. Results

The efforts of H. P. White were a departure from the internally pressurized shot cup. Its efforts, in an attempt to simplify the concept, focused on variations of internal obstructions to the shot column, to create a radial component to the shot pellet velocity. There was no pressurization within the shot cups. Figure 5 shows the shapes of the inserts tested. H. P. White used a 30-in-long (762-mm) barrel with a

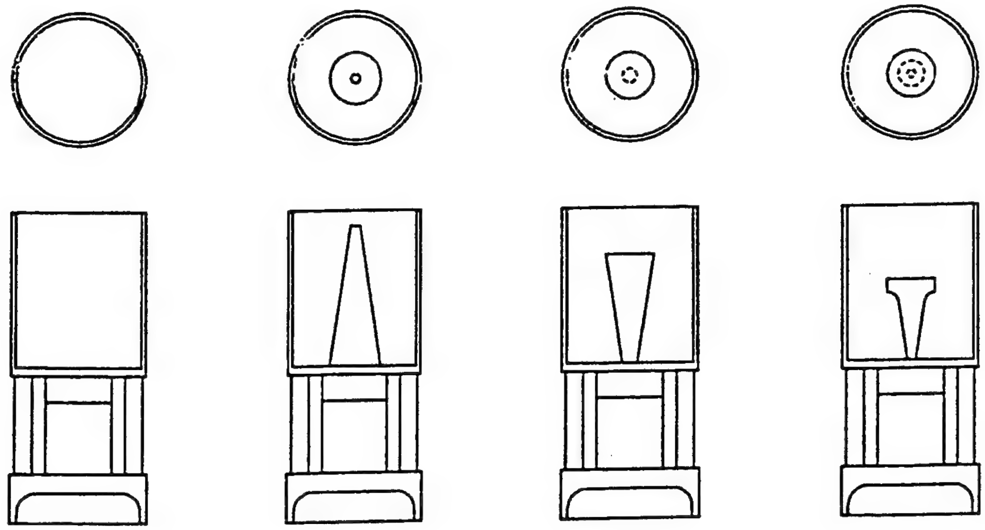


Figure 5. H. P. White insert configurations.

full choke. Chokes are described in Appendix C. They also fired at targets that were 15 ft (4.572 m) from the muzzle. The resulting patterns were all inscribed by a 18-in-diameter (457-mm) circle, well below the desired shot spread. However, it is more noteworthy that although an increase in shot pattern size was achieved, it was at the expense of inline, or axial, energy. Many pellets struck, but did not penetrate the paper target located 15 ft (4.57 m) from the gun muzzle, dramatically revealing their ineffectiveness.

ARL's control shot shell and initial cavity designs produced average pattern spreads of 9.5 × 9.5 in (240 × 240 mm). The damage sustained by the shot cups indicated that the internal cavity was being pressurized (Figure 6), but the impact data revealed this pressurization was not enough to increase the shot pattern size. Damage to plugged cavity shot cups indicated that the unplugged cavities had been pressurized. Table 1 lists the firing results of the various tests. All spreads were, statistically, equal in the vertical and horizontal directions.

The shot cups with the flap check valve design did not produce impact results different from the open orifice designs. This indicated that either the valve was not functioning properly, or the orifice size was insufficient to allow pressurization of the cavity during the ballistic cycle, or both.

The ball check valve design produced patterns with an average spread of 27 × 27 in (686 × 686 mm). Unfortunately, this was still only about half of the desired shot spread.

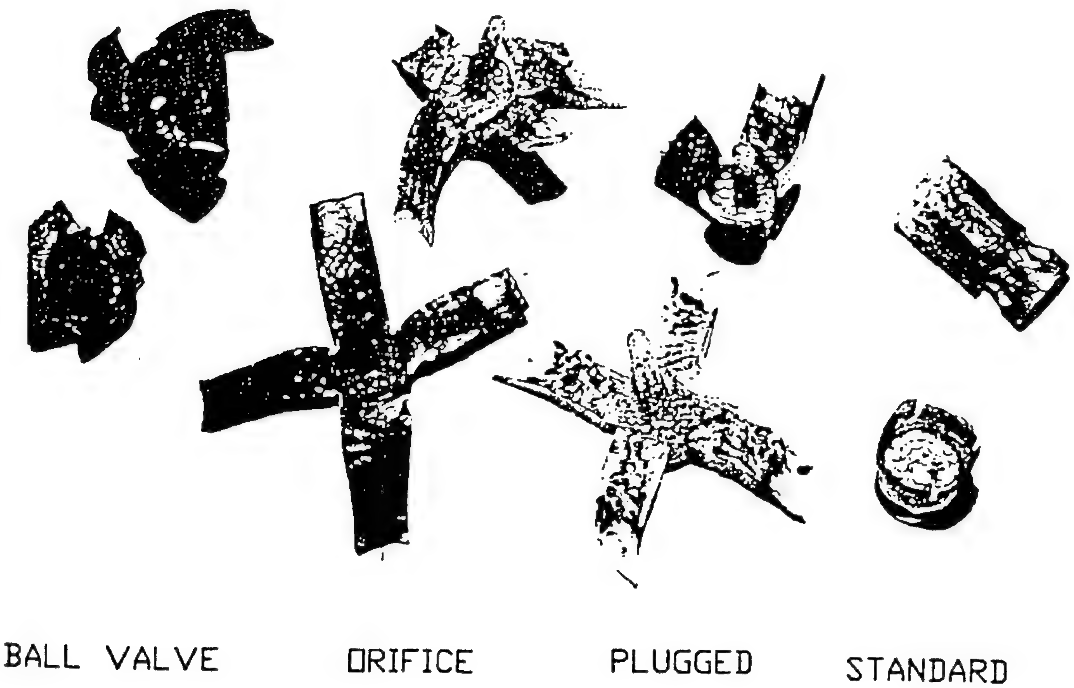


Figure 6. Damage to shot cups.

Table 1. ARL shot spread results.

Shot Cup	Spread (mm) [in]	Remarks
As-received Federal shells	240 [9.5]	—
Reloaded Federal shells	240 [9.5]	Same as previous case.
Pressure tube	240 [9.5]	Some damage to pressure tube wall.
Pressure tube with flap valve	240 [9.5]	No significant difference from previous case.
Pressure tube plugged	240 [9.5]	Reduced damage to pressure tube wall.
Ball valve	686 [27]	Pressure cavity ends failed.

5. Discussion

To achieve the desired pattern, a cavity pressure of approximately 5000–6000 psi (34.5–41.4 MPa) must be achieved and maintained to muzzle exit. The current design fabricated from low-density polyethylene fails around 1200 psi (8.3 MPa) (as

determined from shot spread results and later by finite element analyses). Finite element analysis indicates a redesign may provide about 2500 psi (17.2 MPa) capability. Side wall failures of the cavity dominate the ultimate pressure that can be contained and the loading upon the shot. In order to achieve the desired pressure loading on the shot, greater support of the cavity wall while maintaining loading on the shot pellets must be achieved. It is believed that this could be most easily achieved using another material. A material with high strain to failure capabilities—like an elastomer that could expand out against the shot stack and cup wall—would be desirable. Applying the gas pressure for all practical purposes directly against the shot would be the best solution.

6. Conclusions

A shot cup was designed and tested, which substantially increased the size of the shot impact pattern, utilizing only the propulsion gases as the activation mechanism. While the increase in pattern size is not as great as might be desired, a solid basis for the concept has been demonstrated. It is the belief of the investigators that further investigation into the use of the proper materials will produce an economical and technical solution to provide the desired performance.

7. Recommendations

It is highly desirable that the design of the shot cup be as inexpensive and highly manufacturable as possible. Further development of this concept is needed to provide the final pieces of the puzzle to put the close-combat shot shell into the fielded arsenal of our soldiers in the field.

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Appendix A. Effectiveness of Shot Spread

Because a shotgun produces about five times the muzzle energy of pistols with enough energy to kill people, it seems reasonable to think the shotgun should be an effective weapon against more than one person per shot. The intent of this study is to spread the shot pattern from a shot shell sufficiently to inflict great harm on a large area at very short range. In order to determine what area would be desirable to cover, the available energy of a shot shell was evaluated. Consider the following data.

Examples of near-muzzle energies:[1]

- .22 Short (pistol): 27 gr, 1035 ft/s—64 ft·lb (87 N·m),
- .38 Special (pistol): 158 gr, 910 ft/s—290 ft·lb (393 N·m),
- 9-mm (pistol): 115 gr, 1145 ft/s—334 ft·lb (453 N·m),
- .45 (pistol): 230 gr, 845 ft/s—364 ft·lb (493 N·m),
- .357 Mag. (pistol): 158 gr, 1220 ft·lb—521 ft·lb (707 N·m), and
- 12-gauge shotgun: 1 1/4-oz shot, 1165 ft/s—1646 ft·lb (2232 N·m).

While a .22 pistol can kill someone, particularly at close range, law enforcement agencies typically use .38 special or greater energy handguns. Let 300 ft·lb be the target energy. Consider the following: There is 1646 ft·lb available in a shot shell. At 300 ft·lb/target, there is sufficient energy to strike five targets.

For BB shot, 1 1/4 oz (0.567 g) is about 63 pellets. This yields about 26 ft·lb/pellet available; therefore, to inflict serious injury, at least 12 pellets should impact the target.

For no. 0 shot, 1 1/4 oz (0.567 g) is about 11 pellets. This yields about 150 ft·lb/pellet available; therefore, to inflict serious injury, at least two pellets should impact the target.

For a soldier-sized target, 1.5×1.5 ft or 2.25 ft^2, the pellet area density should be at least 300 ft·lb energy on 2.25 ft^2.

The total area covered would be five targets $\times$ 2.25 ft^2/target or 11.25 ft^2, an area 3.4×3.4 ft. At 15 ft, this would require a half angle equal to arctan (3.4/2/15) or $\pm 8.1°$.*

[1]Sporting Arms and Ammunition Manufacturer's Institute. New York, NY. 1982.

*To achieve $\pm 8.1°$ for BB shot would require a pressure of $8.1/8.5 \times 5572$ or 5310 psi (see Appendix B).

Any further increase in shot spread would significantly decrease the probability of inflicting a serious injury to any given target.

A design goal of 5000 psi was chosen as it would provide a wide pattern spread while increasing the probability of striking the target areas with sufficient impact energy to inflict serious damage. This would yield a half angle of ±7.6° and cover an area 48 × 48 in.

Appendix B. Shot Spread via Pressurization

For these calculations, the assumptions are that the distance from the weapon to the target is 15 ft (4.57 m), a soldier-sized target is 18 in (457 mm) wide, and muzzle velocity is 1275 ft/s.

Shot spread:

To get a three-man width area target from 15 ft (4.57 m):

- Width: ± 2.25 ft (2.29 m) and
- Half angle = arctan (2.5/15) = 8.5°.

To achieve this spread, arctan (Vr/Vz) = 8.5°, where Vr = radial velocity, Vz = muzzle velocity = 1275 ft/s (389 m/s), thus, Vr = 191 ft/s (58 m/s).

To achieve this via pressure loading:

The approximate time for the wad to clear the muzzle is (0.8 in /12 in/ft)/1,275 ft/s) = 0.0000523 s = T. Therefore, assume radial acceleration = 191 ft/s/T = 3,652,875 ft/s^2 or 113,443 g's.

A BB shot is about 0.09 in (2.29 mm) in radius with a weight of 0.00125 Ib (0.567 g). Therefore, it requires about 142 lb (632 N) to accelerate it to 113,443 g's. Using the shot's cross-sectional area, (0.0254 in^2) a pressure of 5573 psi (38.4 MPa) would be required to achieve this force. (Muzzle pressure normally is about 1000 psi [6.9 MPa].)

This calculation, of course, assumes that the force from the pressure loading acts in a purely radial direction.

A design goal of 5000 psi (34.5 MPa) was chosen as it would provide a wide pattern spread while increasing the probability of striking the target areas with sufficient impact energy to inflict serious damage to the targets (see Appendix A).

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Appendix C. Shotgun Terminology

Shotgun types:[1]

Gauge	Diameter of Bore (in)
10	0.775
12	0.729
16	0.662
20	0.615
.410	0.410

Chokes:

Constriction of barrel diameter at muzzle. They typically vary from 0.003–0.040 in.

Choke rating is based on percentage of shot within a 30-in-diameter circle shot at a range of 40 yd (30 yd for .410 shotgun).

- Full choke > 70%,
- Improved modified choke: 60–70%,
- Modified choke: 55–60%,
- Improved cylinder (also quarter choke): 45–50%, and
- Cylinder bore (no choke): 30–40%.

To measure choke, shoot a target at range (30 or 40 yd as appropriate), draw a 30-in-diameter circle around the greatest number of shot holes, determine the total number of shot holes and the number within the circle, calculate the percentage, determine choke rating. Note that the shell, particularly the crimp, will affect the choke rating, so actual choke is not a factor of the barrel alone.

It is the opinion of this author that the idea of the choke is to allow for greater range shooting as the spread is reduced.

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[1]O'Conor, J. *Complete Book of Shooting*. NY: Times Mirror Magazines, Inc., 1965.

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13. ABSTRACT *(Maximum 200 words)*

The theory and design for a shot shell that produces a wider-than-standard shot spread are described. The technique implemented utilizes the pressure generated by the propulsion charge to apply radial force on the shot column within the shotgun barrel, causing an increase in shot divergence upon exit from the weapon. The increase in shot pattern size is intended for application of the shotgun as an area weapon for close-quarter applications, which might occur in military operations on urban terrain (MOUT) or civilian policing operations.

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